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THE OILING OF EARTH ROADS

BY

WILBUR M. WILSON

CIRCULAR No. 11

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THE OILING OF EARTH ROADS

I. Introduction

1. *The Importance of Good Practice in Oiled-Road Construction.*—Approximately forty million gallons of road oil were used on the highways of Illinois during the year 1923. The cost of this oil, applied to the roads, was about three million dollars. It is highly important that a method of road construction involving such a large sum be developed to its greatest effectiveness.

The use of road oil as a means of preserving the roads of Illinois has not been an unqualified success. Some oiled roads have been complete failures, but in the majority of cases a moderate degree of success has been obtained. Many oiled roads constructed by the regular road officials have remained in good condition throughout most of the year. The high degree of success obtained in some cases emphasizes the possibilities of oiled roads when properly constructed and maintained, and likewise emphasizes the economic loss due to inferior practices.

2. *Acknowledgments.*—The investigation conducted on the experimental roads is a part of the work of the Engineering Experiment Station of the University of Illinois. The work has been carried on under the general supervision of Professor C. C. Williams, Head of the Department of Civil Engineering.

An investigation on so large a scale was made possible only by the coöperation of the road officials of Champaign County and by the assistance of commercial organizations interested in road improvement. The Holt Manufacturing Company, Peoria, Illinois, furnished a 10-ton caterpillar tractor and an operator to grade the road; J. D. Adams and Company, Indianapolis, Indiana, supplied a 12-ft. grader and an operator to grade the road, in addition to a 6½-ft. patrol grader to maintain it; the Bayne Manufacturing Company, Bushnell, Illinois, contributed a 6-ft. drag equipped with a two-edged cutting blade for maintaining the road; the Nelson Concrete Culvert Company, Pontiac, Illinois, furnished the concrete culverts at half-price; the Russell Grader Company, Cicero, Illinois, and the Illinois Corrugated Metal Company, Springfield, Illinois, each donated nine corrugated steel culverts.

Various oil companies donated road oil, f.o.b. Champaign, Illinois, as follows: The Empire Refineries Company, two carloads; the Standard Oil Company, two carloads; the Asphalt Sales Corporation, one carload; the Roxana Petroleum Corporation, two carloads; the Cabell Petroleum Company, one carload; the Indian

Refining Company, two carloads; and the Independent Oil Company, one carload.

Mr. John Bateman, Fisher, Illinois, applied part of the oil without charge.

Mr. R. F. Fisher, County Superintendent of Highways, Champaign County, assisted in planning and executing the work. Champaign County bore the expense of improving the road, exclusive of the labor, equipment, and material contributed. The county also provided a patrolman to maintain the road.

3. *Object of Investigation.*—The investigation on oiled roads conducted by the University of Illinois has extended over two years, 1922 and 1923. The 1922 observations were made on a road 12.33 miles long extending north from a road intersection about two miles northwest of Champaign. This intersection is known as Five Points, and the road is referred to in this circular as the Five-Points Road. The 1923 investigation was made on a road 6.5 miles long extending south from the south end of Race Street, Urbana. This road is referred to as the Race-Street Road.

The object of the investigation was to obtain information concerning the failure of oiled roads and to formulate recommendations for the satisfactory construction of such roads.

The conclusions presented in this circular are based upon observations made partly on the experimental roads and partly on other roads in central Illinois constructed by the regular road officials; the practice recommended in this circular has been compared in a general way with that of the most successful of the regular road builders.

II. Description of Experimental Roads

4. *The Five-Points Road.*—The Five-Points Road had not been oiled previous to 1922 and the road was completely regraded early that spring.* The new grade was maintained under traffic by a horse-drawn patrol grader until the oil was applied, the traffic and the work of the patrolman combining to make a well shaped road that, for the most part, was well consolidated and free from dust. The cross-section of the road is shown in Fig. 1.

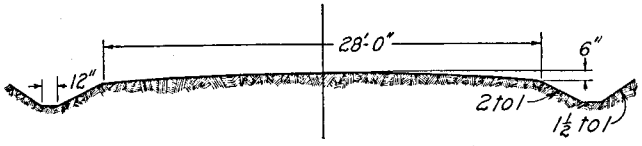

Fig. 1. Typical Cross-section of Experimental Earth Road

Experience during the first season indicates that the road would be improved by increasing the crown to 9 in.

* The grading of this road is described in Circular 10, Eng. Exp. Sta., Univ. of Ill., 1923.

The road was divided into sections 1200 feet long. Each section, as far as possible, was given a different treatment, the variables being (1) the kind of oil, (2) the quantity of oil, and (3) the nature of the soil. The oils are designated by numbers, and the properties of the oils are presented in Table 1. The quantity of oil varied from 1 quart to 5 quarts per sq. yd. The soil, as described on the soil map,* is brown silt loam with narrow strips of black clay loam along streams and at other low places.

The condition of the road in the spring of 1923 is shown by Figs. 2 to 10 inclusive, from photographs taken March 15, 1923.

The effect that the character of the oil had upon the quality of the road was quite apparent. Oil No. 1 was very light, oils Nos. 5 and 6 were of medium grade, and oils Nos. 2, 3, and 4 were heavy. All sections of the road that were treated exclusively with oil No. 1 became very dusty during the summer. The binding properties of the oil were so low that the oiled earth was pulverized by the traffic during dry weather. At the same time the oil prevented the dust from absorbing moisture, so that the rains failed to lay the dust to the same extent they would if the road had not been oiled. Thus the dust accumulated and gradually became worse until sections of the road oiled with oil No. 1 were more dusty than sections that had received no oil. Finally, so much of the surface was ground into dust that holes were formed extending entirely through the mat so that the latter failed to waterproof the roadbed. As a result not only was this portion of the road disagreeably dusty in the summer but it was muddy in the winter and spring.

Figure 2 shows the disintegrated condition of the surface of the section of the road that had received 4 quarts per sq. yd. of oil No. 1, and Fig. 3 shows the excellent condition of the adjacent section that had received 3 quarts per sq. yd. of oil No. 2. The results obtained on these two sections are characteristic of those obtained by the use of light and heavy oils respectively on other sections of the road, and indicate that an oil as light as No. 1 should never be used on such soils.

The effect upon the quality of the road of varying the quantity of oil applied is illustrated by Figs. 3, 4, and 5. The portions of the road shown were all treated with oil No. 2, the only difference in the treatment being in the quantity of oil applied per unit area. The portion of the road shown in Fig. 3 received 3 quarts per sq. yd., the portion shown in Fig. 4, 2 quarts per sq. yd., and the portion shown in Fig. 5, 1 quart per sq. yd. The failure of the road shown in Fig. 5 is due in part to the unfavorable soil conditions as well as to the small quantity of oil that was used; nevertheless, other sections having equally bad soil conditions but which received larger quantities of oil

* Soil Report No. 18, Agr. Exp. Sta., Univ. of Ill.

FIG. 2. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received 4 quarts of oil No. 1 per sq. yd. Failure is attributed to the formation of dust and crumbling of the mat, due to a lack of binding properties in the oiled earth.

FIG. 3. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received 3 quarts of oil No. 2 per sq. yd. It was in excellent condition on the date this picture was taken.

FIG. 4. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received 2 quarts of oil No. 2 per sq. yd. It was in fair condition on the date of this picture.

FIG. 5. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received one quart of oil No. 2 per sq. yd. It went to pieces early in the fall of 1922 and remained in bad condition all winter.

FIG. 6. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received one quart of oil No. 1 per sq. yd. and one quart of oil No. 3. The excellent condition of the road is attributed to firm soil and good drainage.

FIG. 7. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received 3 quarts of oil No. 6 per sq. yd. All of the soil is black, but that in the foreground is lower and more spongy than that in the background.

remained in good condition after this section had failed completely; and all sections that received only 1 quart of oil per sq. yd. began to fail in the fall or early in the winter.

The results obtained by the use of different quantities of oil on the portions of the road shown in Figs. 3, 4, and 5, are characteristic of those obtained on other sections, and indicate that, for a road oiled for the first time, satisfactory results cannot be obtained with less than 3 quarts of oil per sq. yd. except where the soil and drainage conditions are especially favorable.

That the nature of the soil affects the quality of the road is the one fact most clearly established by the investigation. It was found, in every case, that the road on low ground, even when well drained, was not as good as that on high ground where the oil treatment was the same. Apparently the failure was due to the character of the soil rather than to inadequate drainage. This statement is supported by the photographs reproduced as Figs. 6, 7, and 8.

Figure 6 shows the top of a low hill having a firm soil that received only 2 quarts of oil per sq. yd. It was in good condition at all times. In Fig. 7, the part of the road in the background is on a slight elevation, whereas that in the foreground is a little lower, although it has good surface drainage. For both portions the soil is black clay loam, but that in the foreground is spongy even when dry. The part of the road shown in the foreground of Fig. 8, a seepy place on a

FIG. 8. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received 2 quarts of oil No. 5 per sq. yd. The soil in the foreground was well drained, but even when dry it was soft and spongy.

hillside, has had the same oil treatment as that in the background. Failures on low ground appear in general to be due to the spongy nature of the soil. The soil apparently does not have sufficient structural strength to support the oiled earth, and failure occurs by the formation of ruts that eventually break through the mat.

Observations relative to the effect of the nature and condition of the soil upon the success of the road are in accord with experience on earth roads in general. The clear establishment of this fact should, however, suggest to the practical road builder the desirability of giving the low places better treatment than is given other portions of the road. Instead of applying the same quantity of oil per sq. yd. throughout, the quantity should be varied as the condition of the soil requires. Two quarts of oil per sq. yd. on the hills is often more effective than twice that amount on low ground.

One cause of failure that became quite apparent from observations on the experimental road was the separation of the oiled mat from the subgrade. This type of failure occurred most frequently on portions where, during the summer, the surface of the road looked as if it had received a coat of asphalt. When the early fall rains came the water apparently got under the oiled mat, expanding the earth beneath and causing the mat to buckle and crack. This action destroyed the waterproofing value of the mat and, although it healed somewhat under traffic, water from subsequent rains entered the subgrade and eventually caused the road to disintegrate. Figure 9 shows a portion of the road that, from a distance, appears to be in excellent condition, but Fig. 10, a close-up view of the same portion of the road, shows that the surface is badly broken.

The favorable soil conditions on this particular piece of road kept it from going to pieces, but on other sections, where the separation of the oiled mat began to take place early in the fall, the road had completely disintegrated by spring. This type of failure seemed to occur most frequently with oils that were of such a character that the solid residue was deposited on the surface. This cause of failure is important and should be made the subject of further investigation.

5. *The Race-Street Road.*—The Race-Street Road is a main-traveled township road that had been well graded and oiled by the township officials previous to the experimental work that was done by the University, so that heavy regrading was not necessary. The ditches were cleaned early in the spring and the resulting spoil was distributed over the roadway; the road was then maintained under traffic with a horse-drawn patrol grader until the oil was applied. This work resulted in a fairly well-shaped road that was firmly consolidated and free of dust. There were ample side ditches but in a few places the ditches did not have adequate outlets. For a few

FIG. 9. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This section received one quart of oil No. 2 per sq. yd. and 2 quarts of oil No. 3. From a distance the road appears to be in excellent shape, but its true condition is shown in Fig. 10.

FIG. 10. SECTION OF FIVE-POINTS ROAD, MARCH 15, 1923

This is a close-up view of a portion of the section shown in Fig. 9. The oiled mat had separated from the subgrade and disintegrated so as to admit water to the subgrade.

stretches the road was not properly shaped, resulting in inadequate surface drainage. The soil on this road was similar to the soil on the Five-Points Road, described in Section 4.

For purposes of observation the road was divided into 48 sections of various lengths. The road was examined April 6, 1923, and the division points between the sections were so located that the nature of the soil and the condition of the road on this date were practically uniform over the length of each section. The condition of each section on April 6, 1923, was used as a basis for determining the treatment accorded that section, special attention being given to the sections that were in the worst condition. No considerable variation in treatment was attempted, only those practices that had proved successful on the Five-Points Road being used. All the oil was of medium grade and the quantity was varied to meet the soil conditions, a minimum of 2 quarts per sq. yd. being used where conditions were especially favorable, and a maximum of 5 quarts per sq. yd. on short stretches where the conditions were especially unfavorable. The oils are designated by number, and their properties are given in Table 2.

The aim in constructing the Race-Street Road was to build a road that would be as free as possible from the causes of failure that had been observed the previous year; but the effort to eliminate all causes of failure was not entirely successful. There were a few low places that had incomplete drainage; one low place was filled immediately before oiling so that the roadbed had not been properly consolidated at the time the oil was applied; and there were places where the soil was spongy even when dry. From one standpoint, this inability to produce at all points the conditions necessary for the successful construction of an oiled road is to be deplored; from another standpoint the situation was most fortunate in that it brought out still more definitely the relation between cause and effect in the failure of oiled roads.

Figures 11 to 18 inclusive, prepared from photographs taken March 4, 1924, show typical failures that occurred in the road during the winter. The two ruts shown in Fig. 11 were due to low places in the road that would not drain. As the season progressed the depressions became deeper until finally the traffic cut through the oiled mat. The spring rains that occurred after the picture was taken converted these ruts into mudholes that were almost impassable. Figure 12 shows a similar condition at a depressed road intersection.

The bad conditions of the spots having poor surface drainage emphasized the necessity of providing adequate surface drainage for every bit of a road, for a mudhole, even a few rods long, may stall a vehicle and keep traffic from being benefited by the adjacent good portions. Too much emphasis cannot be placed upon the necessity for improving the places that have a tendency to become soft.

FIG. 11. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

This section received 2 quarts of oil No. 8 per sq. yd. in July and 2 quarts of oil No. 11 in October. Traffic broke through the oiled mat at two points where depressions in the road prevented surface water from running off. These spots became almost impassable later in the spring.

FIG. 12. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

This section received 3 quarts of oil No. 9 per sq. yd. in July and 2 quarts of oil No. 11 per sq. yd. in October. The road intersection was so low that the surface water would not run off.

FIG. 13. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

The section in the foreground was in bad condition in the spring of 1923. Three quarts of oil No. 3 per sq. yd. were applied in July and 2 quarts of oil No. 11 per sq. yd. were applied in October. The road went through the winter in excellent condition; shallow ruts formed after the picture was taken but the road remained in passable condition.

FIG. 14. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

This is another section that had been a persistent mudhole. Five quarts of oil per sq. yd. applied to a carefully prepared roadbed carried the road through the winter and spring in good condition.

Figure 13 shows a piece of road that, in previous years, had developed a tendency to become miry. The patrolman took particular pains at this point to develop a good roadbed. The road remained in good condition all winter, as shown by the illustration reproduced from a photograph taken March 4, 1924. Shallow ruts formed after the picture was taken but the road remained in passable condition. Figure 14 shows another piece of road that, in previous years, had been a persistent mudhole. This mudhole, which was quite deep in the spring of 1923, reappeared each time it rained, in spite of continual refilling, but its depth gradually became less and less. The patrolman finally succeeded in getting a firm roadbed; and after receiving 5 quarts of oil per sq. yd., this part of the road remained in good condition, not only through the winter, but also through the spring. Figures 11 and 12 show what is likely to happen if places that show a tendency to become soft are neglected, and Figs. 13 and 14 show what was accomplished by giving special attention to at least two places that had a marked tendency to become mudholes.

Observations on both the Five-Points Road and on the Race-Street Road indicate that the crown of a road settles under traffic in places where the soil is spongy, making it necessary to give a road more crown at such places than is necessary where the soil is firm. The greater amount of crown raises the surface of the road higher above the watertable and also enables the surface to drain completely even after some depressions have formed through the settlement of the roadbed. The typical section used on the Five-Points Road, given in Fig. 1, proved to be a little too flat. For a road 28 feet wide a crown of about 9 inches where the soil is firm, and of 12 to 15 inches where the soil is spongy, is recommended.

The effect of oiling a road that has not been thoroughly consolidated is illustrated in Fig. 15. At the time the oil was to be applied there was a depression in the road on the near side of the bridge that would not drain. Earth was brought in from the shoulders to fill the center of the road and the new fill, 3 to 4 inches deep, was thoroughly rolled with a 5-ton caterpillar tractor. In spite of the fact that 5 quarts of oil per sq. yd. were applied, this portion of the road failed under traffic. In contrast, the portion of the road just beyond the bridge remained in good condition all through the winter and spring. Failure of the portion in front of the bridge is attributed to the few inches of loose earth applied to the center of the road just before oiling. This loose earth, when oiled, failed to form an oiled mat such as is produced when oil is applied to a solid roadbed.

The section of road shown in Fig. 16 behaved in a manner characteristic of many of the low places. This portion had remained in good condition all winter and up to March 4, as shown by the illustra-

FIG. 15. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

This section received 3 quarts of oil No. 7 per sq. yd. in July and 2 quarts of oil No. 11 per sq. yd. in October. On the near side of the bridge the center of the road was filled with a few inches of loose earth just before being oiled; on the far side of the bridge the road was hard when oiled. During the spring the road on the near side was almost impassable, while that on the far side remained in fair condition.

FIG. 16. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

The side ditches have no outlet and water stands in them after rains. The low spot received 2 quarts of oil No. 4 per sq. yd. in July and 2 quarts of oil No. 11 in October, but it went to pieces badly soon after this picture was taken.

tion. A few days after the picture was taken, however, there was a heavy fall of rain and wet snow, and in a short time traffic had formed ruts almost hub deep. There was a fair crown on the road up to the time that it broke up and failure is not attributed to a lack of surface drainage on the roadbed. The side ditches, however, did not have adequate outlets, so that the watertable was only a few inches below the surface of the roadway. The soil, naturally spongy, when saturated with water and subjected to alternate freezing and thawing had but little structural strength. Under these conditions, the traffic formed ruts that soon extended through the oiled mat and finally became quite deep. Unquestionably, the road would have remained in better condition if the side ditches had been provided with outlets so that the watertable could have been lowered. Whether or not adequate drainage would have enabled the road to remain in good condition all through the spring is uncertain.

Figures 11 to 16 have been included in this report because they show portions of the road that failed. It is not desired, however, to give the impression that the road as a whole was a failure. Figures 17 and 18 show stretches that remained in good condition, not only through the winter, but through the spring as well. More than 95 per cent of the road would be classified by the author as good up to March 4, but some of the low spots became rutted and muddy in the later spring.

6. *Causes of Failure of Oiled Roads.*—As a result of observations on the experimental roads and on other roads in central Illinois, the following are considered the most important causes of failure:

(1) The quantity of oil applied was insufficient.

(2) The road was covered with dust at the time the oil was applied.

(3) The roadbed was not thoroughly consolidated at the time the oil was applied.

(4) The oil was of such a character that the oiled earth did not have sufficient binding properties.

(5) The oil was of such a character that the oiled mat separated from the subgrade.

(6) The soil was spongy and the subgrade did not have sufficient structural strength to support the oiled mat.

(7) The road was not properly shaped, and water, unable to run away, formed puddles in the road.

(8) The side ditches did not have outlets, causing the watertable to stand near the surface of the roadway and weakening the subgrade.

FIG. 17. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

A long stretch of road that because of firm soil and good drainage required only 2 quarts of oil per sq. yd. This road remained in good condition throughout the winter and spring.

FIG. 18. SECTION OF RACE-STREET ROAD, MARCH 4, 1924

A long stretch of good road that received 2 quarts of oil No. 2 per sq. yd. in July and one quart of oil No. 11 in October. This road remained in fair condition throughout the winter and spring.

All of these causes of failure have already been discussed except (2). This condition is generally recognized as a probable cause of failure, but it is too often disregarded at the time roads are oiled. In order to understand its fundamental nature it is well to consider that the function of road oil is to form a mat of oiled earth on the surface of the road that will shed water and will not disintegrate under traffic. In order to produce the waterproofing effect the oil must penetrate into the *solid body* of the roadbed.

If oil comes in contact with fine particles of dust, surface tension causes the oil to form in globules covered with fine particles similar to the globules that are formed when water comes in contact with flour. The dust-covered globules of oil resist absorption and often remain practically unchanged for many days, whereas the same grade of oil is absorbed quickly when applied to a solid roadbed. Moreover, if the road is dusty when oiled, the oiled dust is picked up by traffic in an irregular manner so that, instead of there being a uniform layer of oiled dust over the entire road, some portions of the road will have a part of the dust removed and other portions will have additional deposits dropped upon them. This action produces an uneven wearing surface and a surface some parts of which are deficient in waterproofing properties. Even a thin layer of dust is detrimental and should be removed. Dust can be removed very quickly and very cheaply with a grader, and considering the relative costs of removing the dust and of oiling the road, applying oil to a dusty road cannot be justified.

Of the eight causes of failure enumerated, the first three and the last two are under the control of the road builder and may be eliminated by him. The fourth cause, a lack of binding properties in the oiled earth, can be eliminated for soils like the soils on the experimental roads by avoiding the use of light oils. In the opinion of the author, road oils to be used on soils of the character found on the experimental roads should contain not less than 55 per cent of solid residue.

The characteristics of oil that produce the fifth cause of failure, separation of the mat from the subgrade, have not been established. Oils that deposit a large part of the solid residue on the surface seem to be the worst, indicating that an oil should be of such a character that the solid residue is carried down into the soil.

The sixth cause of failure is concerned with the character of the soil and is hard to eliminate. There are, however, practical means available to the road builder that will, to a considerable extent, counteract the effect of spongy soil. Increasing the crown of the roadway gives surface drainage even after some depressions have been formed by traffic; providing side ditches with adequate outlets

lowers the watertable, and thus increases the structural strength of the soil supporting the mat; reshaping the road after each rain, previous to the application of the oil, consolidates the roadbed. All of these processes help to improve the road. Whether or not a road that will remain in good condition throughout the year under moderate traffic can be made on spongy soils will depend upon the season. The author believes that the consolidation and stabilization of spongy soils is an important problem in earth road construction and that it should be made the subject of a separate investigation.

7. *Annual Cost of an Oiled Road.*—To be well maintained, an oiled road must be oiled each year; the cost of oiling is, therefore, a maintenance charge. The annual cost per mile of a high grade oiled road has been determined upon the basis of the following assumptions:

(a) That all culverts have been installed and the heavy grading has been completed some previous year;

(b) that a large grader outfit makes two rounds on the road early in the spring, one round cleaning the ditches and one round distributing the spoil over the roadway;

(c) that the road is maintained by a patrol system for two and one-half months;

(d) that a strip 12 feet wide is oiled at the average rate of 3 quarts per sq. yd.;

(e) that the oil costs 7 cents per gallon applied.

On this basis the annual cost per mile of an oiled road is as follows:

Two rounds of the big grader	$ 10.00
Patrol, 2½ months at $15 per mi. per mo.	37.50
5280 gals. of oil at 7 cents per gal.	369.60
Total cost per mi. per year exclusive of the cost of culverts and the original heavy grading	$417.10

Many roads, because of lack of funds, will be given a less thorough treatment. The method of analyzing the cost of a high grade road may be used to determine the cost of a cheaper construction.

Some counties are oiling a strip only 8 feet wide and are applying an average of less than 3 quarts of oil per sq. yd. Where the traffic is light an oiled strip 8 ft. wide may be sufficient, but where there is moderate traffic the narrow strip will not permit it to be properly distributed. Where the drainage is excellent and the soil is firm over a considerable portion of the road the quantity of oil possibly may be reduced somewhat below 3 quarts per sq. yd.

If the width of the oiled strip or the quantity of oil is reduced, the cost per mile can be adjusted accordingly. It is believed, however, that the figure given, approximately $420 per mile per year, represents the cost of a high grade oiled road that, under moderate traffic and with the soil and drainage conditions existing in central Illinois, will remain in fair condition throughout most of the year. A good road can be obtained at this price only if care is exercised to eliminate causes of failure when the road is constructed.

III. Conclusion

8. *Possibilities of the Successful Construction of Oiled Roads.*— The behavior of a road for one year is not of itself sufficient evidence on which to base a general statement to the effect that an oiled road can or cannot be successfully constructed. Climatic conditions vary in different years; traffic varies in both density and character; the road builder may be more successful one year than another in his treatment of places that have a tendency to become soft. All of these factors have an important influence upon the behavior of an oiled road.

That the winter season of 1923-24 was very hard on oiled roads in central Illinois is apparent from the fact that oiled roads in general did not remain in as good condition as in previous years. It was also the case that some gravel roads which had long remained in good condition disintegrated badly during that season.

The traffic on the Race-Street Road was heavier than usual because traffic from an adjacent road that was being paved was detoured over it. The Race-Street Road is a main road to market and the traffic included a large number of narrow-tired wagons heavily loaded with wheat and shelled corn. In spite of these unfavorable circumstances this road remained in good condition all winter up to March 4, 1924, except for a few short stretches like the ones shown in Figs. 12, 13, and 14, and the failure of these places can be directly attributed to poor preparation of the roadbed. The failures that occurred about the middle of March cannot be so easily accounted for. It is true, however, that all of the places that were especially bad were low places or places where water stood in the side ditches. Some long continuous stretches of oiled roads in central Illinois, built by the regular township and county road officials, remained in fair condition for automobiles all through the spring of 1924. In view of these observations it seems safe to conclude that an oiled road properly constructed may be expected to remain in good condition ten or eleven months out of a year and that, unless the season is especially bad or

the soil and drainage conditions are unfavorable, the road may be expected to be passable for automobiles for the entire year.

9. *Recommended Practice.*—As a result of observations on the experimental roads and on other roads in central Illinois, the following practice is recommended for constructing a high grade oiled road of loam and clay soils similar to those found in central Illinois:

(1) Bring the road to a hard smooth surface each year. If the road is not well shaped it should be completely regraded.* If it has been previously graded, a large grader outfit should be used to clean out the ditches; one round in the ditches and one round on the shoulders spreading the spoil are usually sufficient. This work should be done early in the spring.

(2) Maintain the road with a patrol, beginning as soon as the grading has been finished or the ditches have been cleaned. If a motor patrol is used, a separate outfit should be provided to work on the places that have a tendency to soften.

(3) For a roadway 28 feet wide, give the road a crown of approximately 9 inches where the soil is firm, and of 12 to 15 inches where the soil is spongy.

(4) Delay oiling until the roadbed is thoroughly consolidated.

(5) If the road is dusty, scrape or sweep the dust off before oiling in order that the oil may penetrate into the solid body of the roadbed.

(6) Put on enough oil to make a good road. For a firm soil well drained, 3 quarts per sq. yd. is recommended for a road being oiled for the first time, and 2 quarts per sq. yd. for a road that has been oiled successfully the previous year. Portions of the road where the soil conditions are not favorable should receive 1 to 2 quarts of oil per sq. yd. in addition to the amounts specified above. This additional oil should be applied in the fall and it should be applied to those portions of the road where there are indications of failure.

(7) Use oil that contains a solid residue content of at least 55 per cent.

(8) Apply the oil with a pressure spreader.

(9) Heat the oil before it is applied.

This recommended practice contemplates a road subject to the heaviest traffic that an earth road may properly be expected to carry. It is realized that road officials do not have sufficient funds to oil all

* "The Grading of Earth Roads," Univ. of Ill. Eng. Exp. Sta., Cir. 10, 1923.

the roads in accordance with these recommendations. Moreover, there are many roads that do not carry sufficient traffic to justify the construction of a high grade oiled road that are, nevertheless, of sufficient importance to justify an attempt to make them passable for automobiles throughout the year. No attempt has been made to formulate recommendations for the construction of roads carrying light traffic because sufficient data are not available to answer the large number of questions involved. There are, however, two pertinent facts bearing upon these questions that are quite evident:

(1) In the analysis of the cost of a high grade road, given in Section 7, one-sixth of the total cost is for the preparation of the roadbed and five-sixths for the oil.

(2) Experience teaches that a good roadbed is absolutely essential for the construction of a good road.

These facts indicate that, if the cost of a road must be reduced, it should be reduced by decreasing the amount of oil rather than by neglecting the roadbed. Too much emphasis cannot be placed upon the necessity for having a roadbed that is smooth, well shaped, thoroughly consolidated, and free from dust and loose earth before the oil is applied. One dollar spent on preparation of the roadbed is worth many dollars spent for oil. Parts of the road that are most likely to disintegate should receive special attention, both in grading and oiling.

TABLE 1

PROPERTIES OF OILS*

Five-Points Road

Properties	Oil No.					
	1	2	3	4	5	6
Specific Gravity	0.897	1.037	0.945	0.936	0.935	0.935
Engler Specific Viscosity 32° C.	7.3	223.6	216.5	206.3	70.0	58.5
Engler Specific Viscosity 43° C.	4.4	79.5	71.8	91.7	35.0	30.3
Engler Specific Viscosity 60° C.	2.6	19.0	26.6	26.8	13.1	10.2
Total Bitumen, per cent	99.9	99.9	99.9	99.9	99.9	99.9
Bitumen Insoluble in 86 B. Naphtha, per cent	2.5	11.8	1.5	1.0	7.5	14.1
Fixed Carbon, per cent	3.0	10.4	4.4	3.0	4.3	8.2
Flash Point (open cup), deg. C.	143	177	205	212	119	86
Burning Point (open cup), deg. C.	168	213	234	253	148	103
Solid Residue of 100 Penetration, per cent	38	66	68	66	58	61
Ductility of Solid Residue at 25° C., cm.	8	100	7	14	18	81
Penetration at 25° C.	.....	.....	.....	.....	.....	.....
Nature of Solid Residue	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth

*Analyses were made at the Illinois State Highway Laboratory.

TABLE 2

PROPERTIES OF OILS*

Race-Street Road

Properties	Oil No.				
	7	8	9	10	11
Specific Gravity	1.048	0.927	0.931	0.946	0.958
Engler Specific Viscosity 60° C.	22.2	10.3	6.8	17.3	22.0
Total Bitumen, per cent	99.9	99.9	99.9	99.7	99.9
Bitumen Insoluble in 86 B. Naphtha, per cent	16.1	3.0	4.4	6.5	12.1
Fixed Carbon, per cent	10.3	3.1	4.0	5.0	6.6
Flash Point (open cup), deg. C.	180	193	165	165	130
Burning Point (open cup), deg. C.	210	220	195	195	160
Solid Residue of 100 Penetration, per cent	68	55	59	71	62
Ductility of Solid Residue at 25° C., cm.	100+	50	4	2.5	100+
Penetration at 25° C.	90	120	80	120	100
Nature of Solid Residue	.....	.....	.....	.....	.....

*Analyses were made at the Illinois State Highway Laboratory.

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